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Assessing Risk of Infection & Air Exchange – CO2 Pitfalls, SF6 Benefits

This week we welcomed back Brad Prezant to IAQradio+ to discuss Assessing Risk Infection and Air Exchange. We discussed different methods for doing this type of assessment and go over pitfalls and benefits of different methods.

Brad Prezant is an evidence-based public health scientist with a background in epidemiology, occupational health & hygiene, and ergonomics. Until the company was sold in 2007, he operated Prezant Associates, Inc. in Seattle, providing consulting, training, and laboratory services for 20+ years. He is currently Principal Consultant at PREZANT Environmental in Melbourne Australia. After migrating to New Zealand in 2008, Mr. Prezant spent 3 years at Massey University researching a variety of occupational health issues including solvent exposure to auto body painters, fumigant and VOC exposures from shipping containers, and dust exposures to woodworkers. He previously was Chief Editor of AIHA's first edition of Recognition, Evaluation, and Control of Indoor Mold, an author of several other standard of care documents, and is the Past Vice President for Practice of ISIAQ (International Society of Indoor Air Quality & Climate). He is involved in a wide variety of indoor air quality and occupational health issues, from indoor moisture and mould to ventilation, traditional IH exposure assessment, and infection transmission indoors. He recently managed the hotel quarantine program in Victoria, Australia. He also designed the re-opening of the hotel quarantine program by assessing and remediating the ventilation once they realized they were infecting people because they had not considered airborne transmission.

Nuggets mined from today's episode:

Brad is an advocate of the use of "Risk Calculator" occupant modeling used to predict risks of infection.

The volume of space determines the quantity of infection in air. He studied an airport boarding gate and found the higher ceiling heights are occupant protective.

How does Australia compare to other countries when it comes to keeping COVID cases down?

Australia	United States
7.69 million cases	87.3 million cases
9,200 deaths	1,036,000 deaths
26 million population	333 million population
.03538% mortality	0.3% pop

>95% of Aussies 16 years or older are vaccinated.
>70% of eligible population have received 3 or more vaccinations
Australia is vaccinating 15,000 people daily.

From the US perspective, Australian Government handling of Covid seems draconian?
Australians are more trusting of government and more compliant than Americans. Australia is an example of the successful use of non-pharmaceutical interventions.

COVID BA.5 Omicron variant most common now in Australia.

Australia has had as many Covid deaths this year as in the previous 2 years.

NY Times Article- How Australia Saved Thousands of Lives While Covid Killed a Million Americans.

Brad credits David Bearg's book "Indoor Air Quality & HVAC Systems) for raising his awareness to tracer gas testing and Bill Turner and Jack Spangler for adding to his knowledge.

Tracer Gas is either a present or added substance used to track airflows indoors.

What can be learned from tracer gas testing.

- Quantification of Effective Ventilation Rates (outdoor air entry)
- Quantification of Distribution Inefficiencies in Ventilation Systems
- The Percentage of Outdoor Air in the Supply Air

- Identification of Pathways of Air Movement though Buildings
- Quantification of Re-entrainment into Air Intakes from Nearby Exhaust Stacks
- Measurements of Volumetric Air Flow Rates in Ducts
- Determination of Age of Air Calculations

A good tracer gas is
- Inert, nonpolar, and not absorbed
- Non-toxic, non-allergenic
- Nonflammable and nonexplosive
- Not a normal constituent of air
- Measurable by portable equipment
- Measurable by a technique that is free of interference by substances normally in air
- Relatively inexpensive

SF6 Sulphur Hexafluoride is Brad's preferred tracer gas. The only downside is that the gas has a high Global Warming Potential. Only 60 grams of SF6 is needed to test a small building.

Brad has successfully used theatrical smoke in single story structures and for testing rooftop air handlers for re-entrainment.

Tracer gas testing requirements sophisticated and costly testing instruments with sensitivity in the PPB range. FTIR (Fourier Transformed Infrared Spectroscopy). FTIR scans the entire IR spectrum simultaneously. FTIR spectroscopy quantifies individual gases in a complex mixture to ppb levels. FTIR is quick, sensitive and precise. A system costs approximately $50K+. A multipoint sampler can pull air in from 8 different areas and then present to the analyzer ($10K).

The story of air quality complaints, a de-pressurized below ground fan room, and sewer gas. Brad discussed a case study where tracer gas was used in a medical facility to determine the cause of odor and illness complaints. The building had an underground fan room. During construction, heavy equipment crushed sewer lines. Leaking sewage contaminated the ground and the high static pressure (3"-4") in the fan room drew vapors from the soil through the porous concrete and circulated them within the building. They were able to make this determination by dropping tracer gas into the sewer system.

Tracer gas can be used 3 ways:
- Constant decay method
- Constant emission method
- Constant concentration method

Constant decay curve is the easiest to implement. Tracer is released and a constant concentration is built up in a single zone. Concentration is measured over time Both ASTM [ASTM E741-11(2017)] and ISO [ISO 12569:201] have tracer gas standards.

Overtime tracer gas equilibrates. Tracer gas is the gold standard to establish ACH. Exponential decay. Straight line decay. Why do this? To understand the building, the occupants and the virus using a modeling approach can understand and predict infection.

Focusing exclusively on "Far-field" Transmission…
Key Factors Influencing Transmission Indoors
- Personal factors
  - Generation Rate (measured in quanta)
    - Activity Rate
    - Vocalisation (quanta emission)
  - Dose (Volume * Time)
    - Inhalation Rate
    - Time of occupancy
    - Use of masks
- Virus Characteristics
  - Settling on surfaces
  - Inactivation in air
- Building Factors
  - Size of room (volume in cubic metres)
  - Ventilation (Air Changes per hour, ACH)

The “Compartment Model” simply takes a “box” with known air exchange rate and known source emission rate and solves the maths to determine an airborne concentration.

The “Wells-Riley Infection Model” takes that airborne concentration, factors in time & breathing rate to derive an exposure, and calculates a Percentage Likelihood of Infection (Risk)

Measuring the risk of infection via airborne exposure with simple spreadsheet model
Combine the information Jose Jimenez. From: Jimenez, Jose, et. al., University of Colorado, Boulder http://tinyurl.com/covid-estimator

Covid risk estimated needs to be understood in order to explain it to building owners. Breathing rate of a kid .26, breathing rate of an adult is .52. quanta exhalation rate. Covid variants. Varies 2-4 orders of magnitude between people depending on anatomy, where Covid is present in the body.

Super spreader event is a disadvantageous room or someone is exhaling virus more efficiently. The value is to be able to understand and communicate risks and prioritize corrective interventions.

Focusing exclusively on “Far-field” Transmission…
Factors Influencing Transmission Indoors
Enter building factors, ACHs and building dimensions.

3 Methods of Measuring Air Exchange

- Estimating via Airflow Measurements (design or actual)
- Using CO_2 to Infer ACH
- SF_6 Tracer Testing to Measure ACH

Original HVAC designs are problematic. Not accurately reflected on as-built blueprints, duct leakage, short circuiting, uneven distribution, etc.

CO^2 can be used to infer ventilation rates. Must wait for CO^2 to buildup.
Using Carbon Dioxide to Infer Ventilation Rate

- Number of persons must remain constant & at maximum

- Only at steady-state can the peak equilibrium value be converted to effective ventilation rate
- Time to steady-state can range from 20 minutes to 12 hours
- These conditions are rarely met leading to over-estimates of ACH

CO_2 Measurements May be Giving False Results

Overall air exchange rate and direction of air exchange are important.

CO_2 doesn't accurately measure ACH. SF6 can accurately measure ACH.

Turbulent model used in many HVAC designs. Other strategies should also be considered. Displacement vents save money and are better for infection control than turbulent systems.

Summary:

1. Air exchange can be most reliably measured using tracer gases such as SF_6
2. This provides better estimates than engineering estimates or CO_2 of ACH due to inherent difficulties in satisfying the underlying requirements for using CO_2 –because CO_2 measures two things, ACH and occupancy, and we really only want to measure one thing – air exchange (ACH)
3. With ACH properly measured, risk calculators permit the *percentage risk of infection* from airborne pathogens to be estimated
4. Building owners/operators can rank order their building stock to determine where to intervene using this methodology – and explain these issues simply to stakeholders

Tips:

Testing with CO^2. Test Friday night, remove everyone from the building at the same time. Test for CO^2 and then calculate CO^2 decay. Measure indoor CO^2 versus outdoor CO^2. Can augment testing by adding more CO^2.

Ventilation Optimization AIRAH document

Swedish painters used fan and inflatable bladder to remove paint fumes from building.

Put our minds to work building better buildings.

Have learned things from tracer gas studies that wouldn't ordinarily see or encounter.

In tight buildings in inclement weather zones, open window and doors 5 minutes every hour.

Airline Public Health Initiative. Jack Spangler. Time, ventilation rate, ceiling height, Far-field- concentration lower. Solution to pollution is dilution.

Advocate of UVGI irradiation above breathing zones.

Z-Man signing off